U S E R ' S G U I D E

ORG-115-DA

OPTICAL PRECIPITATION SENSOR

July 2000

OPTICAL SCIENTIFIC, INC.
Tel: (301) 670-2100

205 Perry Parkway, Suite 14
Gaithersburg, MD 20877 USA

Revision Record

Rev Date	Description of Changes
5/30/96	New
7/31/00	Changed company name

Be sure to read the entire User's Guide before proceeding with installation or maintenance of the ORG!

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LIST OF FIGURES

CAUTIONARY NOTES:

Note :
Used to call attention to a special feature or procedure which must be followed for correct operation of the equipment

Caution :
Used to call attention to a concern where damage to the equipment or injury to personnel may occur unless certain steps are followed

Warning :
Used to call attention to a concern where serious personal injury or death may occur unless basic safety procedures are followed

WARRANTY

Optical Scientific warrants its products to be free of defects in workmanship and material for a period of 12 months from date of shipment. During the warranty period, OSi will repair or replace defective products at its own expense, subject to the following conditions:

1. The Buyer prepays all shipping, insurance, and associated costs to return the defective item to OSi. OSi pays return shipping and insurance.
2. The product must not have experienced misuse, neglect, accident or have been altered or repaired by the Buyer during the warranty period.
3. This warranty and OSi's obligation are in lieu of all other warranties. Implied warranties shall not apply.
4. OSi is not liable for consequential or incidental damages, labor performed in conjunction with removal and replacement, loss of production, or any other loss incurred because of interruption of service or production of incorrect or incomplete weather information.

GLOSSARY

A/D	Analog to Digital
ADC	Analog to Digital Converter
AGC	Automatic Gain Control
AWG	American Wire Gauge
ASOS	Automated Surface Observing System
CXR	Carrier
CW	Continuous Wave
DC	Direct Current
FAA	Federal Aviation Administration
IRED	Infrared Light Emitting Diode
LED	Light Emitting Diode
IR	Infrared
MOV	Metal Oxide Varistor
NEMA	National Electrical Manufacturer's Association
NWS	National Weather Service
ORG	Optical Rain Gauge
PSB	Power Supply Box
RMA	Return Material Authorization
RX	Receiver
OSi	Optical Scientific, Inc.
TX	Transmitter
VDC	Voltage Direct Current

ENGLISH/METRIC CONVERSION FACTORS

1 inch = 25.4 mm	1 mm = 0.039 in
1 foot = 0.305 m	1 meter = 3.28 ft
1 pound = 0.454 kg	1 kilogram = 2.2 lbs
°F = 9/5 °C + 32	°C = 5/9(°F - 32)

1. INTRODUCTION TO THE ORG-115 OPTICAL PRECIPITATION GAUGE

1.1 The ORG-115 Improves Your Ability To Measure Rain

Unlike other rain gauges, the MINI-ORG® measures rain rate and provides an analog voltage equivalent to the measured rain rate. It is vastly superior to traditional type sensors and offers the reliability and proven performance you need!

Unlike other sensors, the OSi's ORG-115 sensor provides accurate measurement of rain intensity (rate). Designed for rugged, unattended operation, the ORG-115 has been field proven in adverse environments around the world, on land and at sea .

Optical Measurement Benefits

OSi Optical Rain Gauges are not affected by many of the environmental factors which cause significant errors with traditional rain and snow gauges. Traditional gauges such as tipping bucket, siphon, weighing, and electrical grid type gauges can all be replaced with the OSi MINI-ORG sensors. OSi MINI-ORG's have many advantages including:

- ✓ Easy Installation
- ✓ High Sensitivity
- ✓ Low Maintenance
- ✓ Minimal Wind Effects
- ✓ Wide Dynamic Range
- ✓ No Evaporation or Splash Errors
- ✓ Operate on Ships & Buoys
- ✓ Not Effected by Insects, Debris, Dust

Reliability

The electro-optical design provides for an extremely reliable sensor with a calculated MTBF in excess of 60,000 hours. Unlike mechanical gauges which collect the precipitation to measure it, the MINI-ORG has no collectors, buckets, or siphons to corrode or clog. The sensors use AGC circuitry to eliminate the effects of LED output power or dirty optics. In fact, sensor performance is maintained even when over 75% of the light is blocked! Diagnostics alert the user if the signal strength is too low for normal operation. Preventative maintenance, suggested every 6 months, is as simple as cleaning the 2 optical windows on the unit. The calibration can be verified on an annual basis using the optional OSi TST-800 Series Test Kit. This test can be performed in the field without removing the sensor from the system.

Proven Technology

The ORG-115 sensors are based on technology developed and patented by OSi. OSi was granted patents in the following countries USA 4754149, UK 22001510, and Canada 1285044. This technology is the basis for the present weather sensor supplied to the FAA/NWS/U.S. Navy for the Automated Surface Observing System (ASOS). ASOS is currently being deployed at over 800 airports.

Figure 1.1-1 OSi ORG-115 Series Optical Sensor

ORG® is a registered trademark of OSi.

1.2 Performance Specifications for the ORG-115

The ORG-115 was designed to measure liquid precipitation (rain) rate in above freezing conditions.

The specifications of the MINI-ORG are as follows:

Performance Specification	
Rain Dynamic Range	0.1 to 500 mm/hr - standard 0.5 to 2000 mm/hr - optional
Rain Accumulation	0.001 to 999.999 mm
Rain Accuracy	5% Accumulation
Rain Resolution	Determined by user equipment
Time Constant	15 seconds

Electrical Specification	
Power Requirements	11 - 16 VDC @ 25 ma nominal, 30 ma maximum
Fusing	User supplied 0.125 A Slow Blow recommended
Signal Output	0-5 VDC analog
Transient Protection	All power and signal lines protected by MOV

Environmental Specification	
Temperature	1 to 50°C
Humidity	0-100%
Precipitation/Dust	NEMA-4 type protection

Physical Specification	
Size	506 mm L x 138 mm H x 168 mm W (20 in L x 4.3 in H x 6.5 in W)
Weight	1.6 kg (3.5 lbs)
Cable Length	15 meter (50 ft)

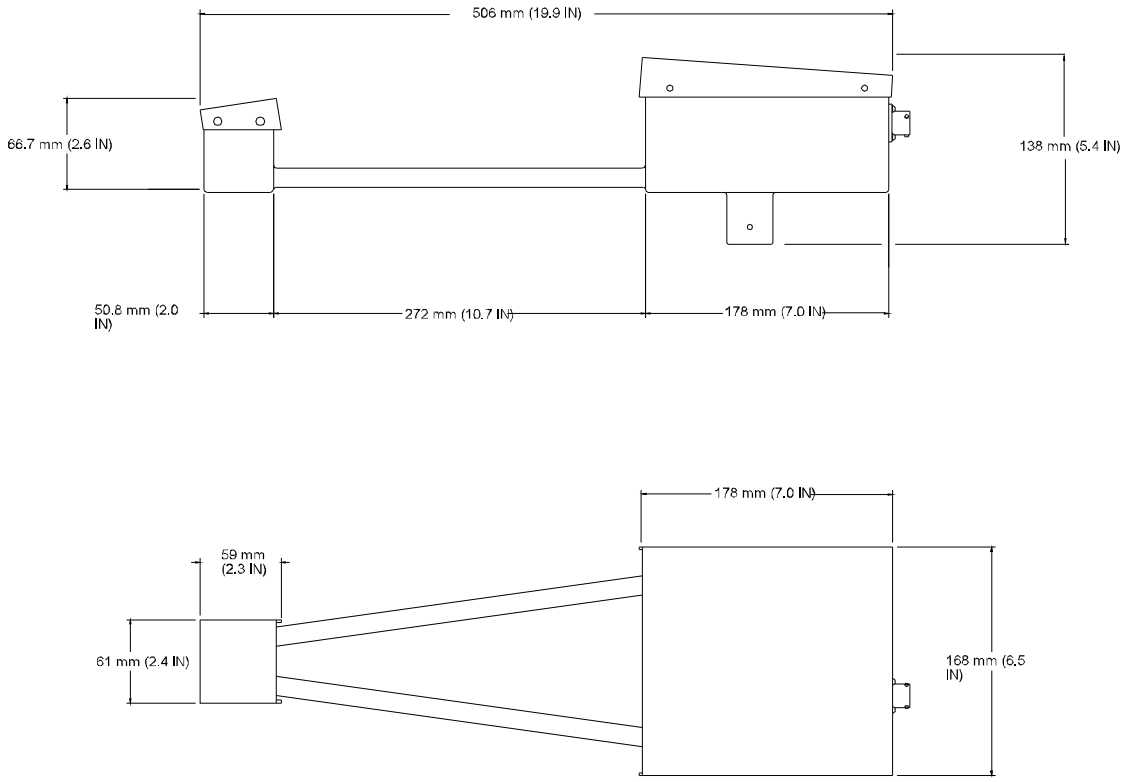


Figure 1.2-1 Dimensions of the ORG-115

1.3 How The MINI-ORG Measures Precipitation

Rain is measured by detecting the optical irregularities induced by drops falling through an infrared optical beam. These irregularities, known as scintillation, have characteristic patterns which are detected by the sensor and converted to rain rate.

OSi's optical precipitation sensors measure rain rate by detecting the optical irregularities induced within the sample volume by precipitation particles falling through a beam of partially coherent infrared light. These irregularities are known as scintillation. The twinkling of stars is a familiar example of scintillation. By detecting the intensity of the scintillations which are characteristic to precipitation, the actual rainfall rate can be determined.

The MINI-ORG consists of 1) a head frame which contains the transmit head, receive head, and electronics and 2) a 15 meter long power/signal cable, P/N 1102-302. The head frame is made from aluminum tubing welded in a v-shape connecting two small boxes that hold the electronics and optics. The small box (transmit) contains an IRED diode and lens. The large box (receive) contains a photo diode, lens, electronics, and connector for the signal/power cable. All wiring between the transmit and receive heads is within the welded pipe head frame.

The MINI-ORG is completely sealed from water intrusion at the factory. Care should be taken to avoid drilling or otherwise puncturing the frame.

Note :
The MINI-ORG contains no user serviceable parts - do not open!

Caution :
Do NOT drill holes in any portion of the MINI-ORG frame!
Doing so will void the warranty and may allow water to enter the enclosure !

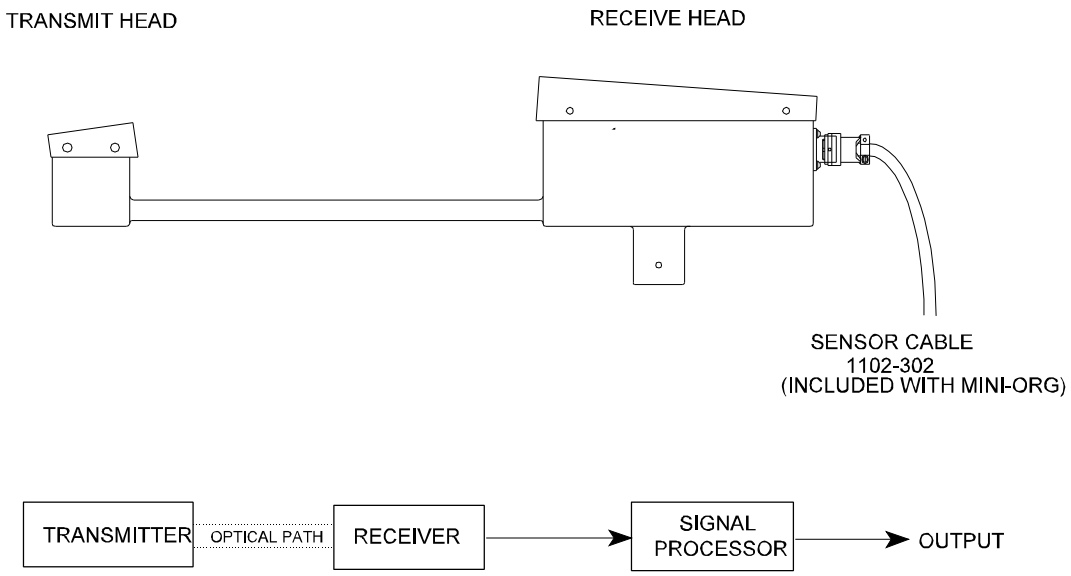


Figure 1.3-1 ORG-115 Major Components

1.4 Accessories For The MINI-ORG

Several accessories are available from OSi for the MINI-ORG. Contact the Sales Office for more information.

Electrical Box

The PSB-715 Electrical Box includes a 12 VDC power supply and terminal strips for connecting the MINI-ORG to the user supplied equipment. Figure 1.4-1 illustrates a typical PSB box.

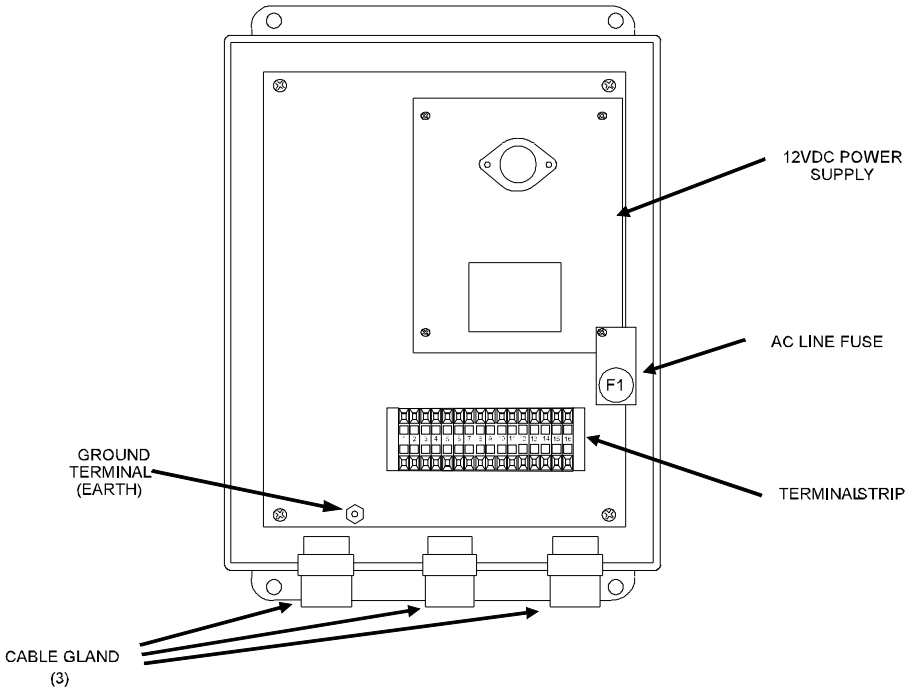


Figure 1.4-1 PSB-715 Electrical Box

Field Test Kit

The TST-800 Series Test Kit provides a convenient way to verify the MINI-ORG operation and calibration. Figure 1.4-2 shows the TST-800.

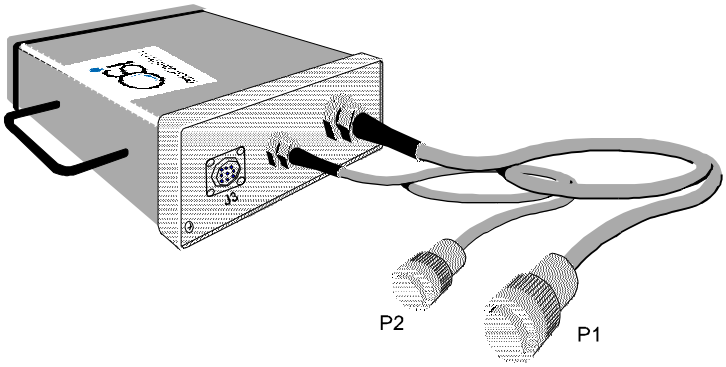


Figure 1.4-2 TST-800 Series Test Kit

2. INSTALLATION OF THE ORG-115 MINI-ORG

2.1 Mounting the MINI-ORG Sensor

The ORG-115 may be installed almost anywhere outdoors but a few precautions will help insure good sensor performance.

The MINI-ORG is packed in a heavy walled corrugated carton that contains the MINI-ORG sensor, cable, and User's Guide. When opening the carton be careful to avoid spilling the contents. Report any shortage or shipping damage to OSi within 3 days of receipt.

Caution :
The MINI-ORG is a rugged instrument but it <u>will</u> be damaged if dropped or handled roughly!

The MINI-ORG should be mounted as shown in Figure 2.1-1. The piece of metal pipe used to mount the sensor should be stiff and well supported so that the sensor does not sway or vibrate in the wind.

The following factors should be considered before mounting the MINI-ORG:

1. **Distance from Obstructions** - The distance between the sensor and obstructions to the wind such as trees or buildings should be at least 2 times the height of the obstruction. For example, the MINI-ORG should be located at least 20 meters away from a 10 meter high tree. This rule is very important for users who want precise rain rates and accumulation because obstructions will block or disturb the rain fall during windy conditions.

2. **Separation from Turbulence Sources** - Be not mount the MINI-ORG near building exhaust vents, steam pipes, or other sources of abnormal atmospheric turbulence that may cause the ORG sensor to report precipitation when none is occurring.

3. **Sensor Height, Rigidity, Orientation, and Verticality** - The MINI-ORG sensor and the mounting base to which it is installed must be rigid. This can be accomplished by mounting the sensor within several meters of the ground with thick wall pipe such as "Schedule 40" type. In general, align the sensor in a north-south line with the transmitter head on the north side (in the northern hemisphere). The sensor must be mounted vertically within +/- 5 degrees so that the line aperture on the RX lens is horizontal.

3. **Availability of Indoor Location** - Be sure to carefully measure the distance that the cable will have to run between the MINI-ORG sensor and the desired cable termination point. The standard cable length is 16 meters (50 feet).

Caution :
Do NOT drill holes in any portion of the MINI-ORG frame! Doing so will void the warranty and may allow water to enter the enclosure!

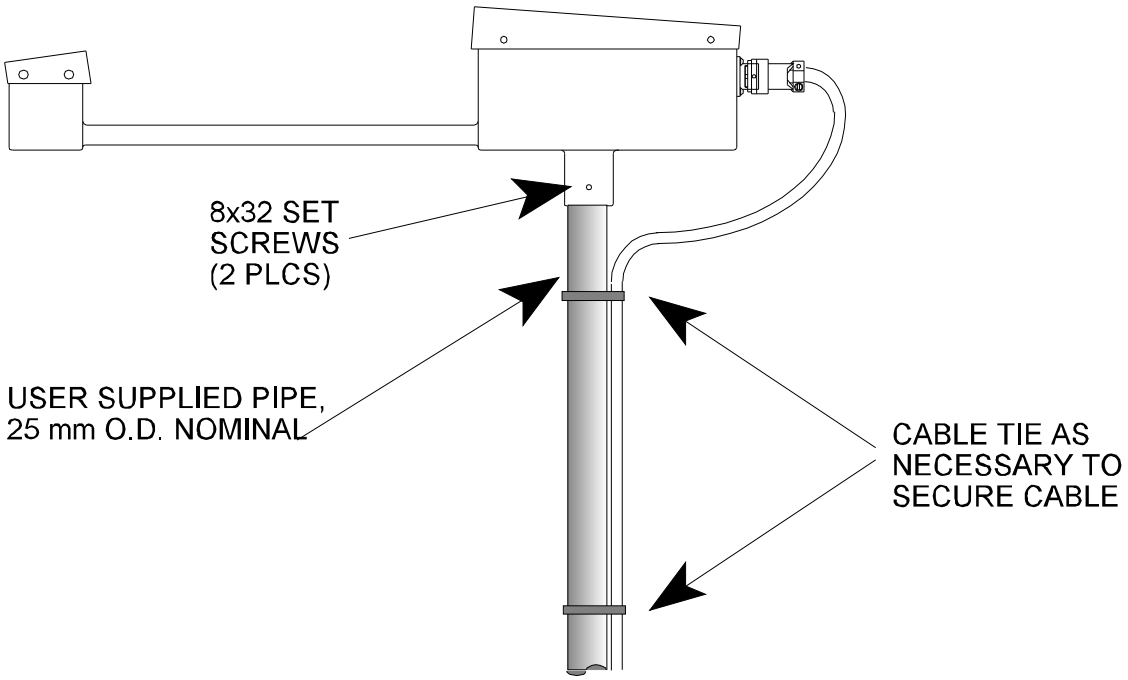


Figure 2.1-1 Mounting the MINI-ORG

2.2 Connecting the MINI-ORG Sensor

Sensor connections are made to the free end of the MINI-ORG cable for all power and signal functions.

The normal installation of the MINI-ORG requires the user to supply a 12 VDC power source and junction box at the end of the cable. The wiring instructions provided here assume that the user is supplying these items. If the MINI-ORG sensor was purchased with the optional PSB-715 Electrical Box, refer to the User's Guide for the Electrical Box for wiring instructions.

Connect the wires in the MINI-ORG sensor cable as shown in the table below and in Figure 2.2-1.

MINI-ORG Wire Color	Function	Connect To User Equipment ...
Red (RD)	+ 12 VDC	Power Supply +12 VDC
Black (BK)	12 VDC Common	Power Supply Common
Green (GR)	Analog Signal Output	Analog Signal Input
Blue(BL)	Carrier (CXR) Signal Output	Analog Signal Input (Optional)
Black (BK)	Signal Ground	Signal Common
White (WH)	Ground	Earth Ground
Black (BK)	Signal Ground	Signal Common
Black (BK)	Cable Shield (2)	Earth Ground

The blue wire carries a diagnostic signal (CXR) that represents the strength of the IRED signal level between the transmitter and receiver. If this signal will not be connected to the user supplied equipment, isolate the wire with electrical tape to prevent it from shorting to another wire.

Warning :
Remember, the ORG-115 requires 12 VDC power. Do not apply 110/220 VAC to the MINI-ORG cable!

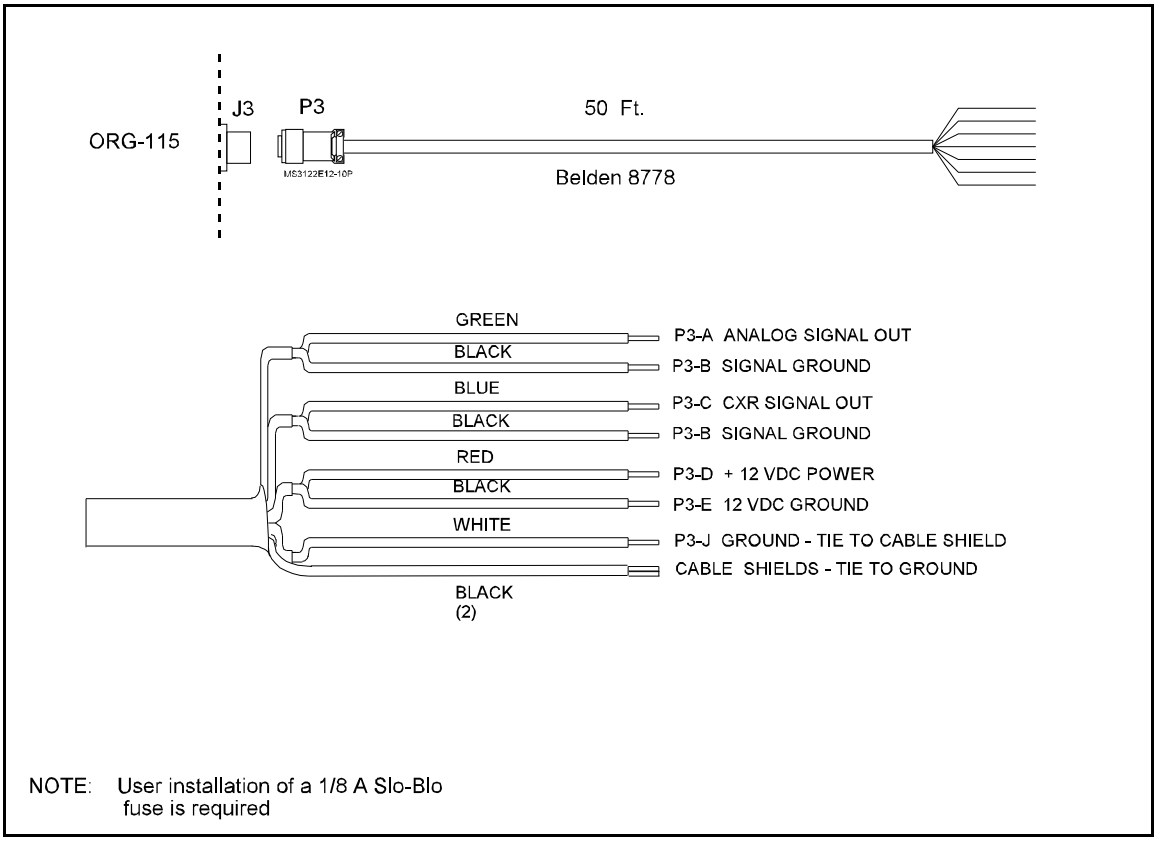


Figure 2.2-1 MINI-ORG Sensor Connections

3. MINI-ORG THEORY OF OPERATION

3.1 Overall System Theory

The MINI-ORG is an electro-optical sensor consisting of optics and analog electronics housed in a weather-tight aluminum enclosure.

A block diagram of the ORG-115 Sensor is shown in Figure 3.1-1. The sensor consists of:

- A transmit modulator and IR Light Emitting Diode (TX)
- A transmitter optical lens assembly
- A receiver optical lens assembly
- A photodetector and preamplifier (RX)
- An Automatic Gain Controlled (AGC) normalizer
- And a signal processor with diagnostic channel

The MINI-ORG uses an infrared light emitting diode (IRED) as a light source. The IRED is modulated to eliminate interference in the system caused by background light. The IRED has a very long lifetime, is relatively low power, invisible to the eye, and presents no radiation hazard to the user.

The IRED is housed in a smaller of the two boxes, the entire subassembly being referred to as the transmitter or source. The IRED is driven by a square wave continuous wave (CW) modulation circuit at 50 percent duty cycle and at a fixed frequency. A lens is used to collimate the IRED's CW modulated light into a slightly diverged beam.

The rectangular box houses the receive optics, DC regulator, the AGC, and signal processing electronics. The receive lens focuses the transmitted light onto a photo diode. The scintillations in light intensity are thus detected and amplified. A wide dynamic range Automatic Gain Control (AGC) circuit normalizes the precipitation induced scintillation signal to the (CW modulated) carrier. This eliminates errors from variations in the source intensity caused by LED aging or dirt on the lenses. The carrier (CXR) signal strength is monitored and made available to the user for diagnostics purposes.

The demodulated scintillation signal is then further filtered, processed, and averaged. The statistical average of the measured scintillation signals give an accurate measurement of the instantaneous rain rates. The rain rate is proportional to the square of the signal voltage.

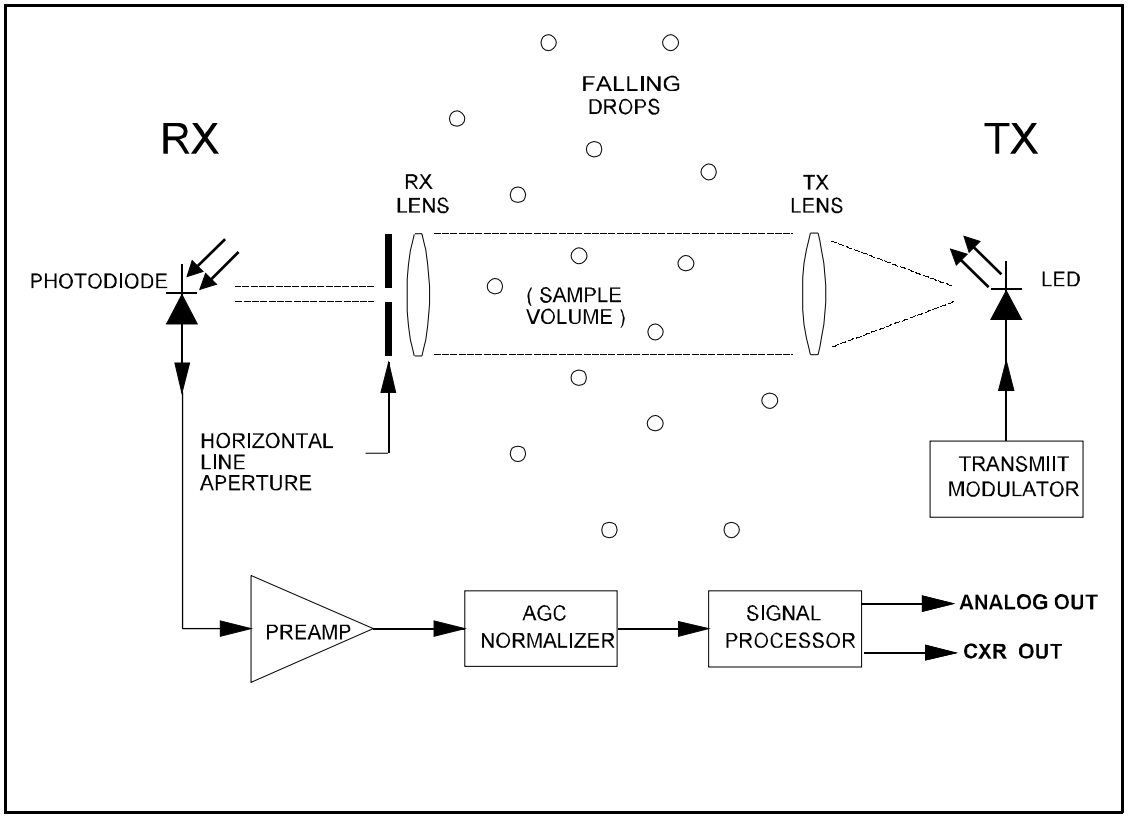


Figure 3.1-1 OSi ORG-115 Sensor Block Diagram

4. MINI-ORG OPERATION

4.1 Sensor Output Characteristics

The rain signal output of the ORG-115 Sensor is a slow-varying (0.066 Hz time constant) DC voltage that is proportional to the square of the rain rate. The actual output level at the signal output pair will vary from 0 VDC to +5 VDC at the extreme limits. The ORG output specification is shown below.

Output Impedance:	50 ohms
Signal Output:	0 to 5 VDC
Time Constant:	15 seconds
CXR Output	0 to 5 VDC
Time Constant	120 seconds

The signal output of the ORG-115 is described by the following formula:

Standard Calibration (500 mm/hr) **Rain Rate (mm/hr) = V_{out}^2 x 20 - 0.05**

Optional Calibration (2000 mm/hr) **Rain Rate (mm/hr) = V_{out}^2 x 100 - 0.25**

where V_{out} is the sensor output in volts DC as the rain varies over the range of 0.1 to 500 mm/hr (standard) or 0.5 to 2000 mm/hr (optional). The table that follows and Figure 4.1-1 illustrate the rain rate to sensor voltage relationship.

Sensor V_{out} (VDC)	Rain Rate (mm/hr)	Rain Rate (mm/hr)
0.085	0.1	.47
0.5	5	25
1.0	20	100
2.0	80	400
3.5	245	1225
4.5	405	2025
5.0	500	2500

Note that the signal output is always positive, with voltages under 85 millivolts corresponding to a "no-precipitation" (NP) condition. This allows use of the most common 0 to 5 VDC unipolar type input of a data acquisition system.

During normal operation, the sensor always puts out some voltage (background noise), even during clear sky conditions. The user should apply the above rain

rate equation only for voltages equal to or above a fixed threshold of 85 mVDC. Otherwise, the user's equipment will report a small amount of rain at all times, due to the "clear sky" output voltage level. ("Clear sky" is defined as the absence of precipitation, turbulence, and other beam disturbances).

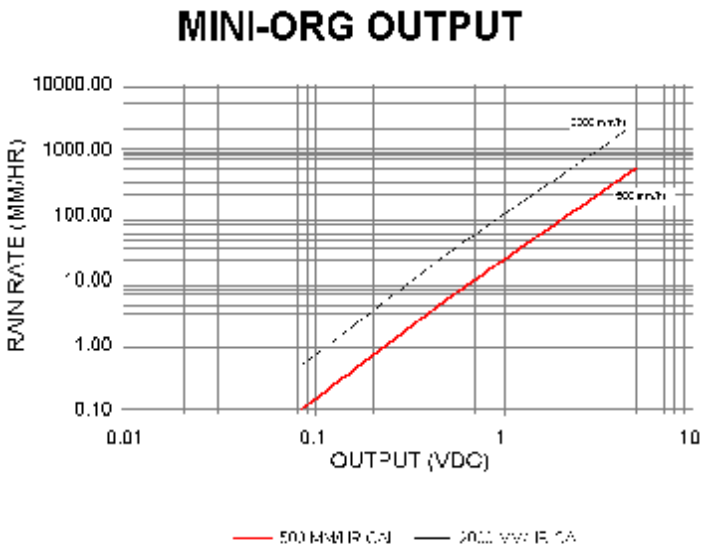


Figure 4.1-1 MINI-ORG Voltage vs. Rain Rate

The diagnostic (CXR) output is an analog signal that can be used to monitor the strength of the IR carrier level. The carrier will fluctuate during rain and therefore should not be used for diagnostic purposes when precipitation is falling. The following table provides a series of thresholds which can be used (optional) by the user. They should be considered a general guideline - for more information, contact the OSi Service Department.

CXR Voltage	Description
4.0 to 4.99 VDC	Acceptable Range
2.5 to 3.99 VDC	Acceptable Range, Check Unit if Decrease Continues
Less Than 2.5 VDC	Maintenance Indicated

4.2 Data Acquisition Requirements

The MINI-ORG can connect to any analog input data acquisition device capable of receiving 0-5 VDC full scale signals.

The data acquisition system used to interface to the MINI-ORG may be a commercial data logger such as those manufactured by Handar, Sutron, Coastal Environment, or similar, PC based A/D boards, or any such device which has an analog-to-digital (A/D) input. To properly sample and record the sensor data, four parameters must be addressed; input voltage range, sample resolution, sample rate, and averaging techniques.

✓ Range & Resolution

For best results, the sensor's output should be digitized with a 10 bit, unipolar analog-to-digital converter (ADC) at an input range of 0-5 VDC. This would be an optimum setup. For a unipolar 10 bit ADC, the digitization error would be 10 bits over 0 to 5 V range = 4.9 mV / step, or about 0.1 % of reading.

At the minimum, the ADC should be a single ended input, 8 bit resolution ADC over the range of 0 to +5 VDC. The error in this case would be 0.4 % of reading.

When connecting the sensor's output to a differential type input, the signal common leg of the input pair is typically not connected to the earth ground because a return path is provided in the sensor. When using single ended inputs, careful cabling and installation practices should be followed to avoid introducing ground loops.

✓ Sample Rate

Since the MINI-ORG's final output stage has a 15 second time constant, the output should be sampled at a minimum of twice that rate, or once every 7.5 seconds to prevent aliasing. This is suitable for all but the most demanding applications where there is an interest in the fine structure of high rate precipitation events. If there is an interest in the fine structure of rain events, sample at a faster rate, such as every 1 to 5 seconds. Many applications do not require such high resolution data and sample rates as infrequent as once per minute are acceptable.

✓ Averaging Techniques

As previously noted, the output of the sensor is a square quantity. If any averaging or processing of the data is to be done by the user's host system, then the raw sensor output data must first be converted to rain rate prior to averaging. If the conversion to rain rate is not done first, the average will always underestimate the true rain rate. For example, averaging the raw voltages of 1.00 VDC & 2.00 VDC (= 1.5 VDC) and then converting to rain rate yields the incorrect value 44.95 mm/hr. Done correctly, converting the voltages to rain rate first (19.95 and 79.95 mm/hr, respectively) and then averaging yields the correct value of 49.95 mm/hr.

4.3 MINI-ORG Operation - A Typical Application

The MINI-ORG outputs an analog voltage which may be converted to rain rate and accumulation.

✓ Rain Rate:

To convert the MINI-ORG voltage output to an equivalent rain rate, use one of the following equations:

500 mm/hr Standard Calibration:

Rain Rate (mm/hr) = V_{out}^2 x 20 - 0.05
Rain Rate (in/hr) =(V_{out}^2 x 20 - 0.05) x 0 .03937

2000 mm/hr Standard Calibration:

Rain Rate (mm/hr) = V_{out}^2 x 100 - 0.25
Rain Rate (in/hr) =(V_{out}^2 x 100 - 0.25) x 0 .03937

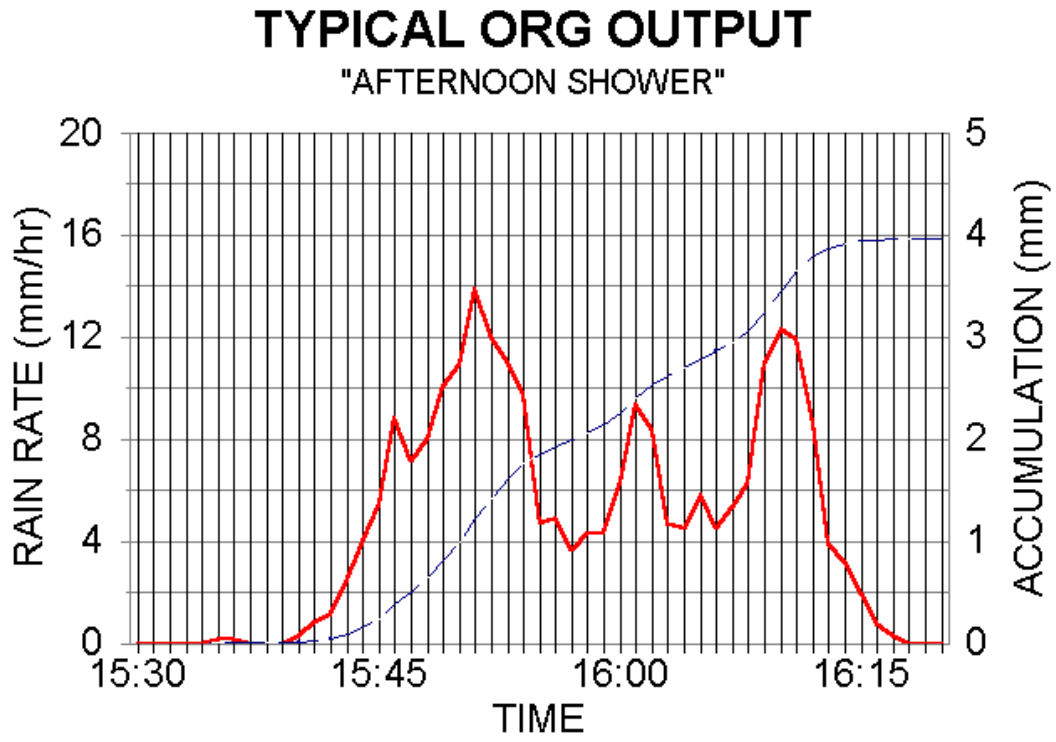
✓ Accumulation:

To obtain accumulation, sum the data points for a fixed period of time and divide by the number of data samples in the period.

If the sensor data is collected once per minute, the hourly accumulation is obtained by adding the 60 rain rates obtained in the hour and dividing by 60.

If the sensor is being collected every 7.5 seconds, the hourly accumulation is obtained by adding the 480 rain rates obtained in the hour and dividing by 480.

A typical rain event was analyzed from data collected by the OSi data acquisition system. A common spreadsheet program was used to generate the graph shown below. Both rain rate (heavy line) and accumulation (dashed line) are shown. Note that the total accumulation for the event was 4 mm.



5. MAINTENANCE & TROUBLESHOOTING THE ORG-115

5.1 Routine Maintenance and Quick Check

The ORG-115 takes only a few minutes every 3-6 months to maintain. In most cases, only simple checks are required.

Equipment Required

1. Clean Cloth or Lens Tissue
2. Common Household Glass Cleaner

The MINI-ORG Sensors are designed for high reliability and low operator maintenance. The only scheduled maintenance is to periodically clean the lenses. In most locations, cleaning the lenses every six months is recommended. Historically, the sensors have operated unattended for several years without any degradation in performance. Use the table provided to record the maintenance performed.

✓ Clean Lenses

Cleaning the lenses should be done with lint-free cloth and cleaning solution. Clean the lenses by first spraying the lens cleaner on the lens and then wipe gently to prevent scratching the glass optics. In actual practice, moderate dust buildup and scratches on the lenses will not have any discernible effect on the instrument.

✓ Carrier Strength (CXR) Check

Check the strength of the carrier signal by measuring the carrier (CXR) voltage on the blue wire. The voltage should normally be from 4.0 to 4.99 VDC if the optical path between the sensor heads is clear and the unit is working well. Partial blocking of the beam will cause the carrier to decrease. The carrier circuit uses a time constant on the order of one-minute and therefore will change quite slowly. If, with clean lenses and no precipitation, the carrier value is < 2.5 VDC, contact the factory.

✓ Background Noise Test

With no precipitation or other movement of particles through the beam, the signal output on the green wire referenced to ground should be <85 mV. The exact value is dependent on the electronics noise of the sensor and atmospheric turbulence around the MINI-ORG. If the background reading is above 85 mV during periods of no precipitation and clear optics, inspect the sensor for proper mounting, grounding, and hook-up. If the problem persists, contact OSi for assistance.

Extremely heavy condensation (dew) on the lenses may cause the MINI-ORG AGC

circuit to increase the background noise above 85 mV. Dry the lenses to clear the optical path and verify that the background level returns to <85 mV.

✓ Comb Test

Using a pocket comb, stroke it up and down vertically in front of the receiver lens as shown below for ~1 minute. Do not block the beam for any length of time. The signal output on the green wire referenced to ground should rise from below 85 mV before the comb test to up to several volts during an extended comb test.

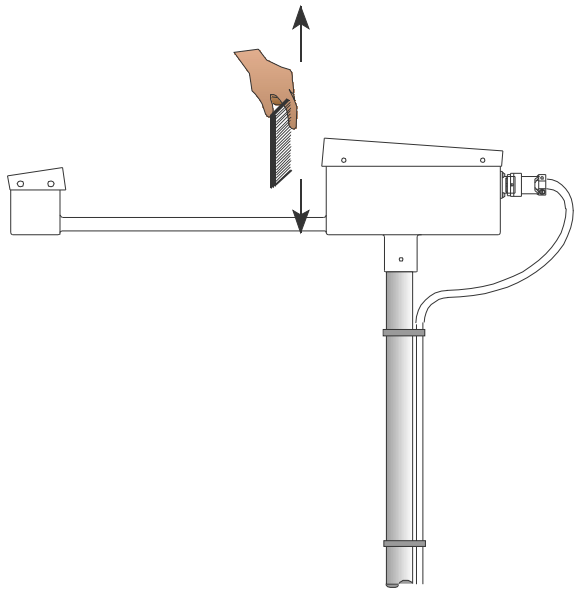


Figure 5.1-1 Comb Test Procedure

Maintenance Check List

	Date _____	Date _____	Date _____
Clean Lenses			
Check Carrier			
Comb Test			

Note :
Remember, do <u>not</u> return anything to OSi without calling first to obtain a return material authorization (RMA) number !

5.2 MINI-ORG Calibration Verification

The ORG-115 calibration can be verified in the field or lab using the optional TST-800 Series Field Test Kit available from OSi.

Complete MINI-ORG calibration is not a user-performed operation. ORG-715 sensors are factory calibrated and sealed and should not be opened in the field. (Opening the unit will invalidate the factory warranty.) OSi provides quick turnaround calibration and repair services for all equipment it sells. Contact the Sales Department for more information on calibration services. For critical applications, periodic verification of the calibration of the sensor is recommended on an annual cycle. Calibration verification requires the use of a TST-800 Series Test Kit.

An abbreviated procedure for it's use is provided below. For more detail, follow the procedure provided with your Test Kit when making the measurement.

1. Turn **OFF** power to the MINI-ORG
2. Connect the Test Kit
3. Turn **ON** MINI-ORG power and wait at least 10 minutes
4. Record the MINI-ORG indicated rain rate
5. Verify that the measured value is correct
6. Turn **OFF** power to the MINI-ORG
7. Disconnect the Test Set
11. Turn **ON** power to the MINI-ORG

Calibration Verification Table

Test Date	TST-800 S/N	Measured Rain Rate	Initial Test Rain Rate	% Delta

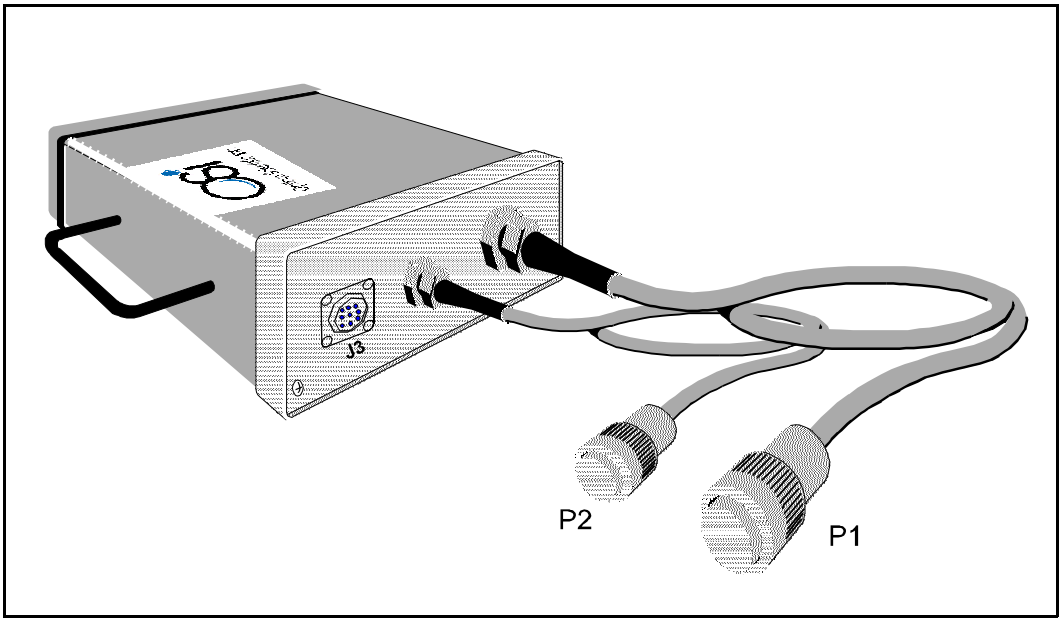


Figure 5.2-1 TST-800 Series Test Kit